

Water Quality Assurances in Milwaukee

Twenty-one years ago on April 7, 1993, the City of Milwaukee issued a boil water advisory on the probability the illness-causing micro-organism *Cryptosporidium* had passed through the city's drinking water treatment system and into the finished water. After seven days, the advisory was lifted, and Milwaukee officials vowed there would never again be a waterborne illness event. The City has kept its pledge to upgrade the Milwaukee Water Works (MWW) water treatment and delivery system and improve water quality monitoring.

The risk of becoming ill from ingesting Milwaukee water has been all but eliminated by an effective, multiple-barrier process of source water protection, ozone disinfection, biologically active filtration, and continuous water quality monitoring. Milwaukee's drinking water quality meets or exceeds all Wisconsin Department of Natural Resources (DNR) and U.S. Environmental Protection Agency (EPA) standards. The water utility's water quality monitoring program tests for many more illness-causing pathogens and contaminants than are required by the EPA.

The events led to improvements worldwide in water quality treatment processes, water quality monitoring, and regulations to protect the public health. In particular, the ongoing partnership between the MWW and the Milwaukee Health Department for water quality monitoring and public health surveillance, ground-breaking at the time, is now recognized nationally for its effectiveness in protecting public health.

Since 1993, the Milwaukee Water Works, with the endorsement of the Mayor and Common Council, has invested \$441 million in water treatment, water quality monitoring, water mains and pumping facilities, real-time monitoring, customer service, and security to ensure high quality water and water service. The Capital Improvements Program prioritizes projects based on results of water-related research, new technology, and condition assessments of existing systems.

The immediate response from 1993-1998 was an unprecedented \$89 million renovation of facilities to strengthen the barriers related to source water protection, disinfection, and filtration.

- The intake in Lake Michigan that provides source water to the south side Howard Avenue Water Treatment Plant was extended 4,200 feet, out of the path of contamination from the Milwaukee harbor. The project cost \$11 million. The extended intake began supplying water from 11,767 feet from shore in 1996. The result was a substantial improvement in the quality of the source water.
- Ozone replaced chlorine as the primary disinfectant at both water treatment plants in 1998. The highly reactive gas destroys illness-causing microorganisms, including *Cryptosporidium* and *Giardia*, and harmful compounds; controls taste and odor compounds, and reduces the formation of chlorinated disinfection byproducts. To expedite the project, the Department of Public Works used a design-build contract for the first time, completing the project within 17 months. At the time, the \$51 million design-build project was the largest ozone retrofit in the world.
- The 32 filter beds at the Linnwood Water Treatment Plant and the eight filter beds at the Howard Avenue Water Treatment Plant were emptied, repainted, and filled with new media of 24" of anthracite coal over 12" of crushed sand to ensure filtration operates at peak efficiency. The dual media system facilitates longer filter runs and improved water quality. The three-year, \$27 million project involved removal of 21,800 tons of gravel and sand. Two acres of underdrain systems and nine miles of surface wash piping were replaced. Further improvements in filter performance were achieved by delivering a polymer to each filter bed after backwashing. The polymer reduces the passage of particulates when a filter is returned to service after backwash.

Additional Changes and Improvements since 1993

1993	2013
Treatment process used coagulation, flocculation, sedimentation and sand filtration.	The utility treats Lake Michigan water with ozone as the primary disinfectant. This highly reactive gas destroys illness-causing micro-organisms and harmful compounds, removes taste and odor compounds, and reduces the formation of disinfection byproducts. Particles are removed through coagulation, flocculation, settling, and biologically active filtration. Chlorine is added as a secondary disinfectant. Fluoride is added to reduce dental cavities. A phosphorous compound is added to control pipe corrosion to prevent lead and copper that may be present in pipes from leaching into the water. Finally, chloramine disinfection maintains a residual in the distribution system to protect against bacterial contamination. Pure, fresh water is delivered at the tap.

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Laboratory staff report to Water Treatment Plant Manager.	<p>A Water Quality Section, directed by a Water Quality Manager, was created in 1995. Staff implements applied research projects to optimize treatment processes and solve water quality concerns in the distribution system. The Section developed comprehensive sampling and analysis plans to improve reliance on, and quality control of, continuous monitoring instrumentation. The Milwaukee Water Works expands water quality monitoring and screening activities to include organisms and contaminants not yet regulated but considered of emerging concern. The utility tests source and treated water for over 500 contaminants while the EPA requires tests for only 91. The monitoring is conducted as a precaution to ensure safe water, to collect baseline data for study, to help increase the understanding of how contaminants may affect public health, and to meet future regulations. The expense of testing for unregulated compounds provides customers with added assurance and confidence in Milwaukee water quality and service.</p> <p>It is impractical for utilities to test for thousands of substances in the environment, many of which occur naturally, that are now being detected by new scientific methods at extremely low levels in drinking water. Science has not demonstrated any impact on human health at the trace levels these compounds are being discovered. Therefore, the Milwaukee Water Works supports drinking water research by the EPA, the Water Research Foundation, and other government and scientific organizations.</p>
Water quality monitoring in the treatment and distribution systems was rudimentary by current standards.	Continuous monitoring replaced grab sampling for many plant process parameters and water quality characteristics. Parameters are available on a second-by-second basis. Comprehensive water quality monitoring program ensures Milwaukee's drinking water quality meets or exceeds all EPA and Wisconsin health standards.
<i>Cryptosporidium</i> was not widely known in the water community. There were no established methods to analyze for it in water, nor local laboratories capable of analyzing for it; there were no regulatory requirements to monitor for it. There were no guidelines for responses to the presence of oocysts of <i>Cryptosporidium</i> in source or treated water.	<p><i>Cryptosporidium</i> is recognized as a waterborne pathogen and is a reportable disease in Wisconsin.</p> <p>Laboratory methods have been established to detect oocysts in water; improvements to the methods are promptly adopted by the Milwaukee Health Department, which analyzes these specialized samples for MWW. Since 1993, over 1,800 samples have been collected and analyzed for <i>Cryptosporidium</i>: 450 each in the source water to Linnwood and Howard Avenue Water Treatment Plants and 450 each in the finished water from each plant. Oocysts have been detected in the source water 36 times, most recently in 2010. Oocysts have been detected in the finished water five times at each plant, most recently in 1999. Unfortunately, the routine laboratory method does not provide information on whether oocysts are alive or dead, or whether the oocysts are of a species capable of infecting humans.</p> <p>There are now guidance documents for treatment process optimization for removal of <i>Cryptosporidium</i>.</p>
Increased turbidity is a surrogate for harmful micro-organisms and contaminants. Allowable concentration for turbidity for treated water must not exceed 5.0 NTU.	Allowable concentration for turbidity of treated water must be less than 0.3 NTU 95% of the time. The median turbidity for Milwaukee water in 2012 was 0.04 NTU.
MWW tap water did not meet EPA requirements for lead.	Systems to control lead and copper corrosion were put in operation in 1996 and MWW has fully complied with EPA regulations since.
	Liquid chlorine replaced chlorine gas for use at the treatment plants. It is safer to use and store, and is accurately metered and dosed. The chlorine system provides the necessary chloramine residual in finished water and is available as a backup primary disinfectant to ozone.
	The Supervisory Control and Data Acquisition System (SCADA) at both plants was replaced in 2008. The system provides treatment plant operators control of water pumping stations and the distribution system. Real-time pressure, power and flow information is provided. SCADA incorporates all chemical feed systems, including ozone, and water quality monitoring.
Filter backwash water was reused at the treatment plants, possibly reintroducing contaminants to the water.	Filter backwash water is sent as waste to the Milwaukee Metropolitan Sewerage District.

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There was minimal interagency contact between the Milwaukee Water Works and the Milwaukee Health Department.	The collaboration of MWW with MHD led to the formation of the Interagency Clean Water Advisory Council (IACWAC). The IACWAC was recognized by the EPA for its work to promote sharing of technical information about water quality and public health-related science, public health surveillance, and situational awareness, analysis, and response. IACWAC tracks and can respond to public health issues that may be related to water.
There were no tools for the U.S. water community to respond to a waterborne disease outbreak.	EPA and AWWA provide guidance manuals and procedures for emergency response planning, training, exercising, and implementing.
There was no external certification program for water plant operators.	MWW has required Water Treatment Operators to be certified, and continuously train to be re-certified, since 2003. Only recently has Wisconsin Department of Natural Resources adopted these requirements.
Customers called water treatment plants with questions about their water.	The Water Quality Section established a Water Quality Hotline, (414) 286-2585, to answer customer inquiries about water quality. MWW also established a Customer Service Center to field customer calls regarding water issues and billing, improving response time and quality of response.

The Milwaukee Water Works is publicly owned by the City of Milwaukee. Policy is set by the Mayor and Common Council. The utility is regulated by the EPA and the DNR for facilities, operations, and water quality; and the PSC for rates and accounting. MWW serves wholesale clients who operate their own water utilities, bill customers, and maintain distribution systems in Brown Deer, Butler, Greendale, Menomonee Falls, Mequon, New Berlin, Shorewood, Thiensville, Wauwatosa, and West Allis, and provides water wholesale to the Milwaukee County Grounds. Retail customers receive full water service, billing and distribution system maintenance: Greenfield, Hales Corners, St. Francis, Franklin (a portion); West Milwaukee receives billing services from MWW and maintains its own distribution system.

Please visit the Milwaukee Water Works website, www.milwaukee.gov/water

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